UAS. Tech. Series No. 38 (Revised)

SOO-BABUL (CHIGURU)

(Leucaena Leucocephala (L) de-Wit)

a multi-purpose plant

K. KRISHNAMURTHY

M. K. MUNE GOWDA

UNIVERSITY OF AGRICULTURAL SCIENCES

BANGALORE-24

1982

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FOREWORD

Ours is predominantly an agricultural country depending on the vagaries of nature Eighty per cent of our people are at the mercy of the monsoons. Dairying is an interl-inked subsidiary enterprise in agricultural occupation. Soo-babul's protein rich nutritious herbage forms an invaluable green legume fodder and feed. Soo-babul (**Leucaena-leucocephala** (L) de-Wit) was first introduced in this University during 1972. Since then research has been initiated intensively on introduction of exotic varieties from Hawaii and USA. Scientific investigations are being carried out at UAS and a fund of research data has been collected. Important findings are that soo-babul can be grown even in extreme drought prone areas and in any type of soil. It grows very quickly and its leaves, pods and seeds can be used as fodder, feed, manure, food etc. The plant is also useful for shade, erosion control, firewood, charcoal, timber, lumber and pulp. The present rate of deforestation may be counteracted to a great extent by afforestation with Soo-babul. Further research is likely to provide more information about this miracle plant.

Toxicity to cattle due to the presence of mimosine in tender leaves of soo-babul has been reported. However, the varieties now recommended are found to be relatively low in mimosine content. Further, the reported ill effect due to mimosine can be avoided by preventing direct grazing and feeding tender leaves. This multipurpose miracle plant is really a boon to our farmers. The UAS has taken a lead in popularising soo-babul in collabora-

tion with KDDC Ltd , Bangalore. About 10 lakh soo-babul seedlings and 3 tonnes of seed have been supplied to the Departments of Agriculture, Forestry, KDDC, public and private organisations and farmers. The main objective of this publication is to provide a reference manual for scientists and development staff of various departments who intend to grow soo-babul as part of their research or development programme.

The authors of this manual Dr. K. Krishnamurthy and Sri M. K. Munegowda deserve commendation for collecting all available information and their research data on soo-babul and putting together in the form of this reference manual for use by all interested to know about soo-babul.

Bangalore
April 8, 1982.

N. G. PERUR
Vice-Chancellor

PREFACE

Dairying is one of the most acceptable and remunerative subsidiary occupations of the farmers. The Karnataka Dairy Development Corporation came into existence in December 1974 and achieved a break-through in the massive milk production programme within a span of few years. The University of Agricultural Sciences is a local consultant to the KDDC and an Applied Research Project on Forage Crops in collaboration with the KDDC, was taken up with a financial outlay of Rs. 35 lakhs. The research findings and the technology developed by the UAS have been taken approximately to 1290 Dairy Co-operative Societies benefitting about 2.23 lakh members. The farmers are encouraged to grow green, nutritious, succulant and palatable grass and legume fodders aiming at the acceleration in milk out-put among the dairy cattle.

During 1977, we got enlightened on Soobabul (**Leucaena leucocephala** (L) de-Wit) and ventured upon this new crop. Sri G. V. Viswanath, I.A.S. the then Managing Director, KDDC, encouraged for selecting, developing and extending the appropriate soo-babul's technology with the farmers of the KDDC command area.

Soo-babul is a leguminous plant gaining popularity all over the world. The current interest of this plant is for fodder and firewood in our state Earlier indigenous species were being grown in gardens & plantations as prop and shade trees. Recently on introduction of exotic strains, its importance became more apparent. During this brief period, several significant factors have emerged. This forage has a very high protein content and is relished by all kinds of live stock. The crop can be grown on any type of soil including

marginal, sub-marginal, denuded, waste, rocky and un-cultivable waste lands. It is doubtful whether we could harvest so much protein rich crop in such lands from any other crops.

Studies made at Hawaii kindled the hopes of using the plant for forage, firewood, charcoal, green manure, lumber, timber, poles, pulp, and so on. The giant strains showed remarkable characters and these are most suited to agricultural and forest related production systems.

Now the name of soo-babul reached all the farmers and landless labourers. The technologies are extended to the grass-root levels at villages with a team of field staff with the aim of increasing the milk production and reducing the cost of it. soo-babul crop is playing a pivotal role in achieving the white revolution. Besides there is lot more to be done on this and exploit its varied uses.

This book deals with the versatile legume whose full potential is still untapped. Further research is needed in areas of agronomy, plant breeding, pastures, animal nutrition, forestry and wood products. Still many tests, trials and development studies are needed to know the extent of the plant's value. Chapter 11 outlines the programmes for research and soo-babul's potential to alleviate major forage, wood and firewood shortages as well as deforestation problems. We hope, the plant will become a multi benefactor to the mankind. The authors are grateful to the Managing Director, KDDC Ltd., Bangalore for financing the project and to bring out this publication, and to all scientists who have helped us, besides to our Vice-Chancellor, University of Agricultural Sciences,for the encouragement.

Bangalore.
April 8, 1982

K. KRISHNAMURTHY
Director of Research

A Multipurpose Plant Soo-babul "Leucaena Leucocephala" (Chiguru)

I. Introduction

It has to be realised that the destiny of farmers depends upon the vagaries of the monsoons. To overcome the chronic problem of under-employment and to improve the economic status of the rural mass, subsidiary occupations are the only solution. Obviously, Dairying, Piggery, Poultry and the like are the acceptable occupations. Amongst all, Dairying is the most profitable enterprise. The farmers' experience has proved that the new cross-bred cows will ideally suit their requirements.

On looking to the increased cattle population of 10.7 percent for every five years, primary attention has to be focussed on supplying nutritive fodder in sufficient quantity. The milk production is comparatively very low due to scarcity of nutritious fodder. Considering the malnutrition and low quality fodder and feed supplied to the animals, the University of Agricultural Sciences, Bangalore (UAS) has undertaken research on various forage crops. The main theme of the UAS is to popularise production of nutritious good quality forage crops among the dairy farming community which in turn helps in reduction of cost of milk production. The area under forage crops in Karnataka is limited to 4.4 percent. Therefore, a planned re-allocation of land use pattern for forage production can make up the deficit. Some improvements such as building up of Agro-forestry system in the

form of green belt around cities, towns and villages, cultivation of top feed trees in the exisiting system in the plantation crops and growing of top feed trees on uncultivated and fallow lands and growing them on tank catchments with pastures to reduce soil erosion can all be considered. These measures will result in additional forage production per unit area of land.

The objectives are :

(i) production of high quality forages for use as green feed or to store as hay or silage.

(ii) feeding programme for animals in different physiological stages in accordance with scientific and economic principles.

(iii) provide high quality low cost feed.

(iv) to take up research on inter-related management practices.

(v) to popularise the nutritious fodder among dairy forming community by applying extension strategy.

(vi) to undertake teaching programme for farmers and those employed in dairy enterprise.

Among different forages tried to evaluate their nutritional value, forage production and utilization, soo-babul tops the list. Keeping in view its performance under various adverse conditions, efforts were made to get the seeds from various countries. The newly introduced species gained considerable prominence and thrived well even under arid regions. Therefore, the U A S intensified its research on establishment, management and utilization aspects of this new forage crop

2. Retrospect

The first reference to **Leucaena** in the agricultural literature was in 1900 when it was mentioned in a report on work in Jawa relating to its performance as a plant for providing shade and maintaining fertility in coffee plantations according to Dijkman (1950). However, Takahashi and Ripperton (1949) reported that the first use of **Leucaena** as a forage in Hawaii was in 1915. According to them, Hawaiian farmers began to broadcast **Leucaena** seed on to beef cattle pastures and only in 1934 a farmer planted **Leucaena** and used plucked branches as a feed to milch animals. Subsequently, during second world war, research in Hawaii was expanded which showed that the plant was a protein concentrate replacement in dairy rations. **Leucaena** is a native of Central America originating in the mid lands of Southern Mexico, Chiapas and Yucatan. It owes its name to **Leucaena** (Oaxace-the home hauxin i.e. **Leucaena**). Until 1961, the species was known as **Leucaena glauca** (L.) (Benth). de-wit (1961) reported that the plant differed in number of stamens and pod characteristics from that now known as **Leucaena leucocephala** and concluded the botanical name for the species as **Leucaena leucocephala** (L) (de-Wit). However, it **(Leucaena)** was introduced into India during 19th century for various purposes (Khan, 1957; Narayan and Shivagnam, 1962; Sinha and Day, 1956).

However, it is only in the last 3-4 years that the potentiality of **Leucaena** as an important forage crop has been recognised and that all efforts are being made to introduce this crop afresh as " **Soo-babul** " on a large scale with our farmers.

3. Botany

Leaves are bipinnate 15 to 25cm long, rachises pubescent pinnate 4 to 8 pairs, 5 to 10cm long, leaflets 10 to 15 pairs,

leaflets linear-oblong, acute, inequilateral, 7 to 15 cm long and 3 to 4 mm wide. The stipules are triangular, glabrous and 15 mm long.

The flowers are white, 100-180 flowers clustered in a globular head, 2.5 to 3.0 cm in diameter, solitory, axillary, long pedicelled and about 4 cm in lenth.

The seed pods are thin, flat strap-shaped, acuminate, 12-18 cm long, 1.4 to 2 cm wide, usually 15 to 60 per cluster, covered with fine hairs when young, with 15 to 25 seeds per pod. Seeds are elliptic, compressed, shiny brown, 3 to 4 mm wide, 6 to 8 mm long and about 2 mm thick. Generally soo-babul plant/tree may reach about 10 metres height. However, the plant characters differ according to environment and are inconsistent and considerable intraspecific variation exists.

Though soo-babul exhibits drought resistance and an inherent ability to withstand repeated defoliation with its foliage providing high protein content and high yields, immediate research efforts are needed on agronomic aspects such as efficient method of establishment, optimum plant population and fertility managment to maximise yield and on utilization aspects to determine the long term effect of feeding soo-babul on animal health. The need of the hour is the production of lines free from mimosine.

4. Species and varieties

With the advent in 1581 of the Spanish galleon trade to the Philippines from the west coast of Mexico, soo-babul crossed the Pacific and became a naturalised shrub in South East Asia. In the 19th century, it was popular as a shade tree in plantation crops and the tree was recognised as a source

of nitrogen. At present it is a leguminous tree adopted widely throughout the tropics.

Leucaena leucocephala is the species **Leucaena leucocephala** (Lam.) de-Wit and belongs to the family Mimosaoceae. The genus includes 51 reported species out of which ten are important. Seven of these originated from Mexico. Out of these, four species viz., **L. diversifolia, L. Pulverulenta, L. esculenta** and **L. leucocephala** are tall growing trees exceeding 15 metres and are used for shade and for browsing in tropical and sub-tropical countries. The remaining species are low shrubs growing up to a height of 5 metres.

All **leucaena** species are non-thorny, high in leaf protein and attractive to grazing animals. **Leucaena Leucocephala** de-Wit is the best known species of the genus **Leucaena**. Though it is being called by many comm on names around the world, it has been named as "leucaena" internationally. A list of species is given in Table I.

Table I. Ten major species of the genus **Leucaena**

Species	First reported Year	Location	Tree height (m)	Leaflet length (mm)	Pod length (cm)
L. leucocephala Lam. de Wit.	1783	America	5-20	10	15-20
L. diversifolia Benth	1842	Venacruz	10	5	10
L. pulverulenta ,,	1842	Venacruz	15	5	15
L. trichodes ,,	1842	S. America	10	10	15
L. macrophylla ,,	1844	Guerrero	5	60	20
L. retusa ,,	1852	Texas	5	20	25

Fig. 1 SOO BABUL PLANTATION - 14 VARIETIES

.. esculenta Benth	1875	Mexico	15	5	25
.. lanceolata Watson	1886	Chilushua	5	20	15
.. shennoni Donn Smith	1914	Salvador	10	20	15
.. collinsii Britton & Rose	1928	Chiapas	5	10	15

Source : Brewbaker, 1976.

Varieties

Salvador type :

Leucaena leucocephala originated in the midlands of Southern Mexico, Guatemala and El Salvador. The native salvador type is often a tall tree and grows upto 20 metres in height and has been called as salvador type. This type produces large leaves leaflets, pods and seeds. The erect habit of salvador type is due to inheritance of monogenic trait. These trees tend to flower only once in a year. They were left behind by man in the native forests and remained unexploited until the year 1960.

''Hawaiian type'' ; These shrubs are highly drought tolerant, branched, abundantly flowering and aggressive woody shrubs, growing up to 5 metres. The plant reproduces with a minimum amount of rainfall of 40 cm. These Hawaiian type came from the Philippines to Hawaii during 1800 (Brewbaker, 1976). These are highly self pollinating and show little abortion or seed, sterility.

''Peruvian type'' : Cultivar peru is a fast growing tree introduced from Australia. The trees are not as vigorous as the ''Hawaiian Giants'' but have a more pronounced basal branching habit. These trees have large leaflets, pods and seeds. As a result of breeding work at CSIRO,

Brisbane, new varieties such as C. V. Peru and K-34 have been released.

"Hawaiian Giants" : Giant leucaenas were discovered Central America in 1910 and named as **Leucaena salva dorensis.** They are arboreal of s a l v a d o r type. Th Giants are distinguished from common types by large stems, leaves, pods and seeds. They mature to abou twice the height of the Hawaiian type. The outstandin giant is K-8. The K-8 strain was obtained from USDA i 1959 as **"L. esculenta"** by its collector from the Guerrer state. It was registered under accession No. P. I. 26369 by the USDA. It closely resembles K-28 from Yucation Maxico K-67 from E-1 Salvador. Different strains have different range o adaptability. These strair s are poor seeders producing seed in one season though flowering twice in a year. The plant i quite attractive both for forage and fuel production. Othe Giants are K-28, K-29, K-67, K-72. Some of the Giants wit their characters are given in Table II.

Table II. Details of the Giant types of soo-babul

Strain	Origin	Type	Character
K- 4	Guatamala	Peruvian	Low branching type
K- 6	New Guinea	Peruvian	Low branching type
K- 8	Mexico	Salvador	The "Hawaiian Giant"
K- 45	Colombia	Hawaiian	Mimosine about half norma
K- 62	Ivory coast	Peruvian	Good low branching type
K- 67	Salvador	Salvador	A Good Giant type
K- 72	Hawaii	Salvador	A more seedy Giant type
K-340	Hawaii	Hybrid	Partially sterile. Low mimosine
K-341	Hawaii	Hawaiian	An aggressive Hawaiian Giant type

Sourcee : Brewbaker, 1976.

However, Gray (1968) reported that the defferences among the arboreal and shrubby strains of leucaena are probably simple in inheritance and it is possible to breed to any desired growth habit.

5. Climate and soil requirement

Soo-babul grows wild upto 5000' elevation in high rainfall areas of 2000 mm per annum. In Karnataka, soo-babul does not grow well in elevations above 5000'. Hutton and Gray (1959) reported that soo-babul could be grown in Australia in areas which had a summer rainfall of above 762 mm and where July mean temperature did not fall below 10 °C, whereas Whyte **et al.** (1953) found that it could be grown in Ceylon upto 2540 mm rainfall zone. One common feature of soo-babul is its ability to flourish on soils with neutral to alkaline pH and to grow even on rocky soils with little top soil. The plant is well adapted to a wide range of soil types. However, it fares well under well drained soils. It is observed that in Karnataka, soo-babul grows on almost any type of soil ranging from rocky to heavy black clay soils with a range of pH from 5.5 to 8.5. The crop, however, does not tolerate water-logged conditions. Though the crop can be raised under high rainfall region, it is more productive at lower elevations.

There is a notion that soo-babul can be grown on all types of soil and topography ranging from narrow valleys to flood plains, rolling hills and mountains with gentle to steep slopes. Hill (1971) states that soo-babul flourishes on alkaline soils even with thin top soil and rocky feature. The crop grown at MRS, Hebbal (Rocky hillock behind Veterinary Hospital) and ARS, Nagenhalli Research Station showed varying degrees of growth and development in varied habitat. It can grow on any terrain and type of soil provided that the annual rainfall does not exceed 3000 mm. The plant thrives on crevises of rocks and in all well drained soil types and series. However,

it is observed that the rapid growth and development occur in deep and fertile soils in low lying areas.

In Karnataka, the soils used for growing soo-babul are generally low in fertility. The well developed deep tap roots reach 2 metres depth within one year and 7 metres in 5 years. Brewbaker (1976) indicated that the tap roots reach down as deep as water table. The research results indicated that the crop favours a deep loose soil for full development and vigour In light soils the roots spread out laterally and rest on an impervious sub-layer. When they penetrate into hard substrata, they absorb soil nutrients from deep down the soil profile.

The roots are well developed in light textured soils. In heavy clay soils, root ramification has been observed resulting in poor vegetative growth. Neutral to slightly alkaline soil reaction favours good establishment of the crop. Its early growth is more severely affected in acidic soils as could be seen in the Viswaneedam Farm near Bangalore. This poor growth is attributed to lack of P, Ca and molybdenum. The crop requires large quantities of P and Ca. In case of high CEC soils, the fertilizer requirement for crop is high. A high CEC enables the soil to retain relatively larger quantities of plant nutrients resulting in better growth. Further study is required in this aspect. The slow growth during initial establishment may be attributed to phosphorus non-availability for normal development. The application of phosphorus in acid soils enhances the growth. Thus soil with substantial quantities of available phosphorus are condusive to vigorous growth. Adequate quantity of boron and molybdenum micronutrients are essential for higher forage yield. As a forage crop, soo-babul requires substantial quantities of Iodine and cobalt which are needed by animals.

Studies in mineral nutrition of soo-babul are few and interest in this aspect has to be kindled for detailed investi-

gation. It is obvious that low soil pH, low phosphorus and low calcium levels and high aluminum were the limiting factors. To confirm these effects, an integrated approach on this aspect has to be undertaken. For the establishment and maintenance of good stand, the fertility status of the surface soils as well as lower soil horizons should be ascertained. Calcium nutrient plays a dominant role in determining the dry matter yield in the forage crops. Plants that were limed and treated with pho phorus had the highest yield of dry matter. Murraman and Peach (1968) reported that lime caused the release of aluminium bonded and iron bonded forms of phosphorus, but decreased the phosphate concentration. Further studies are needed in this behalf.

6. Establishment of soo-babul crop

Soo-babul crop has been widespread throughout the country in three patterns viz. (1) as dispersed trees in waste lands, (2) as shade plants in beetle vine gardens and plantation crops and (3) as hedge trees. The scattered trees survive with their foliage above the browsing level of the animals.

The establishment of soo-babul crop is mostly by seeds or seedlings and occasionally by vegetative cuttings. For forage purpose, the crop is established either by seeds or by seedlings. It is difficult to establish the crop by vegetative cuttings as their rooting capacity is only twenty-five per cent.

Soo-babul crop is highly self fertilizing and its seeds breed quite true from individual plants. Careful selection of outstanding plants must be made to isolate true varieties.

Land preparation : It is desirable to have the land thoroughly prepared free of weeds. This is a must when soo-babul is planted by direct seeding. In hilly areas it is recommended to plant seedlings by digging pits of 45 x 45 x 45 cm. size.

Seeds ; Soo-babul seeds are often infested with seed weevils. The seeds must be treated with malathion, methoxychlor or sevin for long term storage. The seeds should have less than 12 per cent moisture as otherwise moulds develop rapidly. The seed of soo-babul has a hard seed coat. The hardness increases with the length of the storage period. As the period of storage increases, the seed becomes heavier and results in poor germination. To ensure better germination, seed treatment is a must.

Seed treatment : The untreated soo-babul seeds usually have a germination of less than 5 per cent. The seed coat is hard enough to prevent moisture intake. The seed treatment can be performed in following ways :

(a) Heat treatment : The simplest treatment for large seed quantities is the hot water technique. Water is brought to a vigorous boiling stage and poured over the seeds in a volume ratio of 4 :1. The water is allowed to cool and then decanted off. The heat expands the seeds by cracking the seed coat. All alternative method is to heat the seeds in water at 80° C for 5 minutes.

(b) Mechanical scraching : The seeds should be nicked without injuring the embryo. They may also be rubbed against sand or rough stony surface.

(c) Acid treatment : Treat the seeds with commercial sulphuric acid (80% purity) for 10 minutes and wash the seeds thoroughly. This is a costly method.

Seed inoculation : The treated seeds should be inoculated with right type of **rhizobium** culture depending upon the soil reaction. CB-81 strain is recommended for acid soils and NGR-8 or NGR-35 for alkaline soils for better establishment

of crop and fixation of nitrogen. After inoculation, seeds should not be exposed to sunlight nor kept long. Inoculation of seeds should be made just before sowing.

If **rhizobium** culture is not available, soil from beneath the soo-babul trees which are known to be nodulating effectively can be used in new sites. Effective nodules on soo-babul plant roots are usually about 6 mm in diameter with several lobes which are pink or red inside.

Seedling establishment : The treated seeds should be properly dibbled in the soil for its successful emergence and subsequent growth. Seeds sown not exceeding 4 cm depth have the maximum emergence. In light soils, 2-3 cm sowing depth is preferable to deep sowing.

Nursery propagation : The nursery soil should be mild acidic to mild alkaline i.e. pH 5.2 to 8.5. If the soil has pH less than 5.0, sufficient quantity of lime should be added to raise the pH. Soo-babul seedlings can be raised in containers or in nursery beds.

The seedlings can be raised in polythene bags of size 20 x 12 cm or 15 x 10 cm with three holes at the bottom. The bags should be filled with a pot mixture of 1 : 1 : 1 (red earth : sand : compost) and one sprouted seed is to be allowed per bag. The bags may be placed in shade and watered regularly. After one month, seedlings may be exposed to sunlight and watered once in three days. If nursery beds are prepared, drill the seeds 4 cm apart from seed to seed in rows of 25 cm. Preferably the seed beds should be trenched and filled with sand or humus, then to provide adequate drainage so as to minimise the damage to the tap root system of the seedlings.

Time of planting : Sowing or planting can be taken up at the beginning of the rainy season. If irrigation facilities

Fig. 2 EMERGENCE OF SEEDLINGS IN POLYTHENE BAGS

are available, this operation can be continued round the year. However, sowing/planting operation should be avoided if the mean temperature falls below 10° C in that region.

Some seed bed problems like damping off of seedlings may occur during wet season. To overcome this problem, sowing time has to be manipulated so that seedlings are planted during hot season.

Care of young plants : Care should be taken to keep the area planted with the soo-babul seedlings free from weeds till they reach the height of one metre. Once the crop establishes, it suppresses the weeds.

Site Suitability : Though soo-babul grows under varied adverse conditions, generally the crop responds well to lime and phosphorus application particularly in acidic and low fertility soils. Application of lime and phosphorus as basal dose promotes better plant growth. In acidic soils, application of lime brings pH up, Lime must be applied first prior to phosphorus fertilization. Acidic soils render the phosphorus not available for plant use. Soils rich in available phosphorus encourage the plant growth and help in root nodulation. It may be side dressed at the rate of 24 kg. per hectare. In denuded soils, response to molybdenum and sulphur for better crop establishment was observed.

ENVIRONMENTAL EFFECTS ON FORAGE YIELDS :

Several environmental constraints influence the forage production. They influence the decisions on time of harvest or controlled grazing. Kinch and Ripperton (1962) estimated the water use of 54mm per ton of dry matter, The studies undertaken at MRS, Hebbal, reveal that the reduction of water was closely correlated to reduction of yield. In prolonged moisture stress condition, the leaf drop was observed. The

Fig. 3 MAINTENANCE OF NURSERS

moisture stress can be observed during the initial establishment of the crop but later on roots penetrate to the water table. The moisture stress was observed to be more severe on high yielding varieties. The water logged soils are considered detrimental. Soo - babul strains thrive if good drainage is provided at the initial crop establishment period.

Soo-babul survives in cool climate but leaf drop was observed if temperature fell below 10° C. The native and planted crop's growth rate impairs at higher elevation. Kinch et al. (1951) found that plantings made at sites of 2° C temperature produced lower yields per year. The crop growth rate and yield were reduced in the cooler, low light winter months. The frequency of harvest also varies. The crop can be hervested at 60 days interval in summer and during winter months at 100 days. Therefore low light and low temperature affect plant growth and forage yield.

FERTILIZATION : Though the crop tolerates low soil fertility, in many situations, it responds well to fertilization. The crop appears to tolerate wide range of soil pH but prefers a soil with higher pH to low one.

NITROGEN : The plant being a legume, draws the nitrogen needs from symbiotic nitrogen fixation. Therefore normally, nitrogen fertilization is not in practice excect to provide a small amount at the time of sowing/planting. However, the seeds are inoculated with a right type of RHIZOBIUM strain.

PHOSPHORUS : The phosphorus requirement may be drawn either by native phosphorus or supplemented through phosphate fertilization in phosphorus deficient soils. In acid soils, phosphorus availability is low. Therefore, phosphorus fertilization is a must as a basal dose as well as once in two years during the crop growth. Nitrogen fixation depends on the availability of phosphorus in the soil.

Fig. 4 SEEDLINGS - READY FOR PLANTING

POTASSIUM : The plant requires huge quantity of potassium nutrient. In potassium deficient soils, application of potassium is very essential.

CALCIUM : The growth of soo-babul is impaired in calcium deficient soils. In acid soils, application of lime enhances the crop growth.

MAGNESIUM : The required magnesium nutrient is drawn from the soil and there is no need to supplement the same in our condition.

SULPHUR : The sulphur deficiency resembles that of nitrogen. The forage crops require huge quantity of sulphur nutrient. Especially, the soo-babul crop is very sensitive. However, application of super phosphate supplies the required quantity of sulphur to the crop.

MOLYBDENUM : Molybdenum deficiency is observed in acid soils. It also affects the nodulation. Application of lime and molybdenum is found to increase nodulation.

ZINC : Soo-babul tolerates low level of zinc nutrient but good establishment of the crop could be seen after zinc fertilization.

However, fertilization may be done on studying the initial soil fertility status, Application of lime and phosphorus, boosts the growth and establishment of a newly planted soo-babul crop in acid soils. Phosphorus is usually needed in soils to encourage the growth of soo-babul crop for forage purpose. Application of phosphorus at 24 kg ha once in two years maximises the forage yield.

7. Management systems

Soo-babul has spread naturally to become a dominant plant in lower rainfall regions. It is also easy to plant and manage, Management requirements of soo-babul depend upon the particular use for which the crop is grown and the different ecological situations, Based on this, management systems are classified as follows :

i) Management system for forage

ii) Management system for maximum biomass production

iii) Management system for Kaingin farming

iv) Management system for wood and chorcoal production

v) Management system as reforestation crop

i) MANAGEMENT SYSTEM FOR FORAGE

Soo-babul (LEUCAENA LEUCOCEPHALA (L) de-Wit) is a leguminous tree capable of producing nutritious fodder to the cattle. The forage produced from the crop is highly palatable. The ability of the plant to withstand repeated defoliation makes it an ideal forage crop. Edible dry matter production varies from place to place and is also influenced by the amount of rainfall received in that region. Soo-babul crop dominates in our ungrazed natural grass lands. While growing for forage purpose, the planting of seedlings is done in rows and regular clipping is carried out. The produce is used either as green fodder or as hay. The virtue of this system is that, through this management, green forage is continuously harvested from strips round the year. Animal grazing is wisely controlled to provide a balanced grass/legume feed. The management system in solid stands is similar with respect to fertilization, weed control and rate of cutting for maximum yields.

Fig. 5 K-63 STRAIN FOR FORAGE

In the first management system for forage, soo-babul crop is grown in natural grass lands and grazing by cattle is allowed. The second category is the "cut and carry system". As the land holdings are too small, the cut and carry system is quite common in Karnataka. The soo-babul seedlings are grown in hedges and trenches. The branches are cut-off to produce new leaves from time to time. Therefore, the farmer has to envision the planting of seedlings in very thick densities in rows and hills. The green forage is chopped off once in 50-60 days and is fed directly to live-stock or dried for leaf meal. Keeping in view its forage quality, the breeders have evolved varieties with low mimosine content. Several environment constraints influence the forage production The forage yield mainly depends on the time of harvest or controlled grazing. Forage yields increase greatly with increasing height as the plants expand to intercept more light. The cattle fed on sole soo-babul forage gain their body weight But at times some adverse effects are seen on animal health. This hindrance can be overcome by growing varieties containing low mimosine.

(ii) MANAGEMENT SYSTEM FOR MAXIMUM BIO-MASS PRODUCTION

Pen feeding is quite common in Karnataka. Planting seedlings in rows with regular clipping or controlled grazing is the simplified way for obtaining maximum yield. The rows of soo-babul plants are kept 2 to 4 metres apart and the interspace is planted with guinea, blue panic or green panic grasses. Animal grazing must be controlled to provide a balanced grass-legume feed. The grass also benefits from the presence of a legume plant. Mendoza **et al.** (1975) stated that flail-chopping equipment can be used effectively over hedge rows to reduce the woody stems and induce the lateral branching which help in the dairy management. Therefore, frequency of harvest is very important in determining

the yields and quality of soo-babul leaf meal. Studies conducted at MRS, Hebbal also reveal that frequent cuttings with an interval of 50 days, at a cutting hight of 150 cm. would provide maximum yield. Harvest frequency is best judged by the height of forage re-growth. Total yields of an 'Hawaiian type' K-63 are greatly increased as cutting heights are increased from 15 cm to 150 cm (Table III).

Table III. Forage yield (green) of Soo-babul in t/ha (Mean of two years)

Frequency	Height 15 cm	Height 75 cm	Height 150 cm	Mean
40 days	16.90	28.15	23.99	22.78
50 days	28.33	37.78	37.00	34.37
60 days	33.88	31.10	41.77	35.58
70 days	34.73	35.12	48.34	39.40
Mean	28.28	33.04	37.78	33.03

Source : Krishnamurthy **et al.** 1982.

Maximum yield can also be obtained from the soo-babul crop raised in neutral soils with adequate phosphate fertilization. Oakes (1968) stated that soo-babul has a high feed value either as cut hay or green chop. Even the young twigs of soo-babul chopped well serve as cattle and sheep feed. Approximately half of the total forage is from leaf meal. Henka (1958) stressed the value of soo-babul's leaf meal and reported increase in milk production from the milch animals fed with soo-babul fodder. For yield maximisation, soo-babul sown one metre apart and cut back every two months produced 120 tonnes of green forage. The young stem and leaves can also be dried and pulverised as leaf and stem meal. The production depends on the spacing or the density of planting and management has to be regulated as per the objectives of raising a crop.

Fig. 6 CUTTING HIGHT AND FREQUENCY REGIMES IN K-63. SOO BABUL CROP

(iii) MANAGEMENT SYSTEM FOR SCIENTIFIC KAINGIN FARMING

To meet the demands of food and energy, new devices have to be adopted by utilizing the steep lands and mountain sides. The ways to increase food production by combining cereal crops with forest crops have to be undertaken. Soo-babul fits into the existing condition in improving the present system of farming in the mountainous areas. After burning the growth of forest, soo-babul is planted or directly sown in rows of to 6 metres apart depending on the gradient of the slope. Later on, any agricultural crop can be planted between the rows of soo-babul plants. The best suited crops are maize and sweet potato. The branches of soo-babul are cut back at intervals and can be used as forage, green manure and mulching material. For a Kaingin management, soo-babul should be a source of green forage for animals. Weed menace in this system should be checked. Therefore, the destructive Kaingin management can be changed over to the scientific Kaingin management which prevents soil erosion and enriches the soil. While selecting the site for the kaingin system of management, land classification and the status of the land has to be determined. Applied research on the hill side will have to be made. The research findings on soo-babul and its use in the systematic kaingin farming have to be transferred to the hill side farmers.

(iv) MANAGEMENT FOR WOOD AND CHARCOAL PRODUCTION :

Soo-babul plantation is an excellent source of fuel wood and charcoal both for domestic and industrial uses. It can also be used as fence and house posts, props for commercial banana plantations. pulp wood and other valuable wood products. Benge (1975) reported that Giant soo-babul grew 13 metres tall with an average breast height diameter of 37 cm in eight years. Further, soo-babul is usually found in areas with distinct dry season periods of 4 to 5 months.

The management for wood production can be conducted in three ways, namely (a) direct seeding in furrows, (b) direct seeding by broadcasting and (c) planting seedlings on the plantation site. The first method requires ploughing once but the second method can be followed either by broadcasting the area without burning, broadcasting in strips after burning the area, or broadcasting after burning the area. Planting of seedlings is found to give better results. In this management, harvest or cutting is the clear felling system. Any other system is more expensive and laborious. Curran and Racelis (1936) observed that the yield of soo-babul stands from seedlings exceeded the sprout-stands. They reported that the 7 year old stands from seedlings yielded 175 cubic metres while similar 7 year old sprout stands yielded 158 cubic metres or a difference of 17 cubic metres.

Research on the utilization also plays an important role in the proper management of plantation for wood production. It has been recognized that soo-babul is good for firewood and charcoal because of its high heating value. The rate of growth is one of the key factors affecting the density of wood The general opinion is that fast growing trees would have lower specific gravity than the slow growing trees planted in the same site.

The soo-babul trees are expected to be ready for charcoal after four years of growth. An important way to overcome the present energy crisis is to restore the wood supply through the planting of fast growing varieties like Hawaiian Giants. Most fuel wood today comes from the natural forests and depletion of these forests is in progress due to excessive cutting for fuel wood. Expansion of the fuel wood plantations and establishment of new ones would help to meet the demand for fuel wood.

(v) MANAGEMENT SYSTEM FOR REFORESTATION CROP :

Soo-babul is an ideal plant for re-forestation purpose. All the grass lands, unproductive lands and denuded areas can be

restored to their productiveness by planting with soo-babul crop. Reclamation of such areas is also often difficult because of adverse conditions prevailing in the site area. Continuous soil erosion, leaching of plant nutrients and frequent burning of forest have resulted in converting them into sterile soils. Soo-babul seedlings survive even under unfavourable conditions and due to their fast growth, ress the competing vegetation in short time. Soo-babul has been observed to flourish in areas that have been devoid of top-soil, in road cuts and in rocky slopes where roots penetrate deep into the horizon layers. It draws water and nutrients from the greater depth and fixes nitrogen in barren lands. This legume, thus has almost all the qualities of a good reforestation species.

In the management system as reforestation crop, sowing of seeds on the site is most desirable. Seeds be drilled or dibbled or the seedlings aged about six months may be planted to establish the crop. In direct seeding method, roadent menace should be taken care off. The seeds get in contact with the soil and improve the condition for rapid root penetration. The time and method of sowing are important because they determine the availability of soil moisture to the seedlings. However, dibbling or drilling of seeds on the site seem to be superior to broadcasting. Rats a d goats should be kept away from the site. The production of seedlings in the nursery and then planting on the site helps in better establishment of the crop.

Soo-babul's gregarious growth habit and production of seeds in copious amounts, capable of sustained longevity render the plant invaluable as a nurse crop in reforestation. It also helps in soil and water conservation and in soil improvement capabilities. It serves as a cheap source of green manure, forage and fuel. In addition ro providing shade, the presence of soo-babul species stimulates the planted forest trees to attain height rapidly. However, the management

Fig. 7 SOO-BABUL FOR SOIL CONSERVATION

system for reforestation requires less land preparation. Seed bed preparation is recommended for the establishment as a nurse crop, a cover crop, forage or green manure crop as well as for raising a hedge or wind break. For reforestation purpose, seeding is done on the ridges, allowing natural spread down the slopes. Seeding is done at the onset of monsoon and seed rate varies according to the sowing method adopted. Soo-babul seedlings are also planted in grass lands to serve as a shade tree for cattle and to provide fire break.

However, systematic production research will have to be initiated on the inputs-requirement for good establishment, cultural practic s for the management for fire wood, charcoal. distillates, paper pulp, lumber, timber etc, These areas of research on the crop throw light on its multibenefactor character during the present day energy crisis.

Soo-babul has many utilization aspects in day to day life. As quoted by Zabala (1971) its usefulness to a person's life is from "birth to death". It is being used as food, feed, fuel wood, charcoal, fertilizer, timber, shade crop, wind break hedge, cover crop, nurse crop and green manure crop. It has immense value in soil improvement, soil reclamation, refore-station and in medicine and industries. Therefore, as quoted by Benge (1978) "Hunger is not the tragedy of an empty stomach but it is the tragedy of a human mind not used". Soo-babul is not an universal remedy for all the problems but maximum benefits can be gained by growing perennial tree crops coupled with annual food crops as part of an agro-fore-station system.

8. Utilization

1. Pasture crop
2. Green fodder
3. Animal feed

Fig. 8 SOO-BABUL FOR RAVINE RECLAMATION

4. Organic fertilizer
5. Reforestation
6. Wood production
7. Charcoal production
8. Fuel
9. Fire break/wind break
10. Fencing/shelter belt
11. Fibre
12. Distillate products

1. PASTURE CROP

The grazing system of utilization of the soo-babul is as important as cut and carry system. Efforts are under way to introduce soo-babul species combined with native grasses like Guinea, Cencrhrus, or HETEROPOGUS CONTORTUS. It is an excellent plant for growing in grassy areas due to its ability to withstand competition with perennial grasses. The crop can be set in the field as pure stand or mixed with grasses. Leaf canopy of soo-babul allows sunlight to filter through thus allowing certain grasses to grow. It is observed Guinea grass interplanted with K-63 soo-babul variety carries one animal per 0.4 ha. But grazing systems have to be regulated allowing rotational grazing, letting livestock to stay and graze in each compartment for 3-4 days.

Soo-babul has slow growth rate compared to grasses. Because of the upright growth habit of soo-babul, grasses get established. Further herbage quality is better than pure grass stand without any reduction in yield because of possible benefits from nitrogen fixation by soo-babul. Jones (1976) states that the carrying capacity of pastures is high once soo-babul is fully established and it varies from 3 animals per hectare in sub-tropics to 6-7 animals in tropics. Soo-babul

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has a long growing season and it stays green in dry season. The fodder is quite palatable to livestock. It is not easy to over-sow into native grasses. All soo-babul species are non-thorny, high in leaf protein and generally attractive to grazing animals. The bushy non-photo-periodic, early maturing, heavy seedling. bushy varieties are valuable for forage in pastures. Row spacing varies widely from 0.3 m to 1.3 m or as wide as 3 m to 4 m for grazing when intercropped with cereal crops. Plant spacing in the row also varies widely from 15–20 cm to 1 m.

Grazing should not start till the plants are one metre high. Continuous overgrazing will impair the herbage production. Undergrazing will promote tall woody stems which cannot be grazed by cattle. Therefore careful management is necessary to maintain any pasture as a productive one. Sometimes the plants do not produce herbage because of overgrazing. Under such conditions withdrawing the animals from grazing and resting the pasture is necessary.

2. GREEN FODDER

Recently soo-babul has drawn the interest of many people because of its nutritious forage value. This was as a result of the introduction of fast growing high yielding varieties "Hawaiian Giants" from Hawaii University and their popularisation by the University of Agricultural Sciences, Bangalore. Among the fast growing soo-babul strains disseminated from Hawaii are K-8, K-67, K-72, Peru and K-340. Earlier soo-babu leaf meal was used by many farmers for fattening the livestock. These are raised along fence lines, boundaries or in their gardens. Before feeding the herbage, the branches are chopped finely and mixed with rice bran, cut grasses, rice straw or maize/jowar stover.

In an experiment conducted at the UAS, herbage yield of soo-babul ranged from 19 tons to 40 tons per hectare per year

with cutting intervals of 40 days to 70 days. This can easily support 20 animals a year assuming a 25 per cent soo-babul fodder feeding. It is better to supply it as green fodder rather than processed leaf meal. On introduction of Hawaiian Giants, the green fodder yield varied from 60 to 100 tons green herbage per year. Brewbaker (1975) also mentioned that Hawaiian Giants yielded 94.26 metric tons of fresh herbage. The plants grown as hedge plants are usually harvested by a chopper and lopped herbage is than brought to the feed lot and given to the animals as pure or mixed with grasses or sugarcane tops.

At MRS, Hebbal, Bangalore, a field trial was conducted employing three cutting heights of 15 cm, 75 cm and 150 cm. The results of research gave significantly higher yields at a height of 150 cm with days interval. These results underscore the importance of maintaining a higher stubble height to allow more buds to develop into new branches. When soo-babul is grown as a pure stand for forage purpose, about 100,000 to 130,000 plants per hectare are needed to obtain higher yields. Though the leaf meal is well accepted by livestock, it is low in sodium and iodine. By supplementing it with pangolas, digetaria species, kazungula and setaria could correct the low sodium intake in soo-babul fodder.

However, it is reported that the toxic amlno alkaloid mimosine complex substance is found in all cultivated forms of soo-babul varieties. High concentrations are found in the actively growing parts of the plants such as growing tips, young leaves flowers, young pods and seeds. Studies on the effects of environmental and nutritional factors in determining the mimosine concentration in the plar ts parts are under way in the UAS, Bangalore. In the meanwhile, diluting the mimosine concentration in the fodder by drying of the cut forage has been undertaken. It is observed that the reduction is greater if drying is prolonged due to the breakdown product 3, 4-dihydroxy pyridine (DHP).

Studies are also underway on feeding of soo-babul leaf meal to poultry birds, swines and sheep in the UAS, Bangalore and so far no adverse effects on animal health have been observed.

The soo-babul herbage value is enhanced because of its high crude protein content, high phosphorus and calcium contents. Now farmers are quite aware and understand that as long as there is no regular provision for high quality nutritious fodder in the livestock production, their socio-economic status in the society will not be improved. Therefore they have made up their mind to supply the soo-babul green forage either as cut and carry system or browsing in the fields or as mixture in the natural grass lands.

3. ANIMAL FEED :

There is no commercial production of soo-babul leaf meal or pellets to replace the expensive cattle feed coming from the industries. Dairy farmers make sparing use of leaf fodder of soo-babul as it is not available commercially at a competitive price. Protein levels generally exceed 25 per cent in the leaf portion, averaging around 15 per cent in green stem and 7 per cent in coarse stems. Carotene values are very high and so is vitamin A. The alkaloid mimosine is often mentioned as a major deterrent to the feeding of soo-babul leaf meal. It is in fact, not a serious toxicity hazard and its bad effect can be avoided. Cattle and sheep fed on a balanced grass-legume ration show no ill effects. However, sole or heavy intake of soo-babul fodder or feed should be avoided to reduce flavouring of milk. In Philippines soo-babul leaves are being used as a feed component since early sixties. Recently large scale manufacture of feed has been intensified in view of introduction of varieties/strains which contain very low mimosine. Its leaf meal is a very valuable component of animal feed. In swine nutrition, 5 per cent level of leaf

meal in the rations shows good growth and development. Nutritional studies on the utilization of soo-babul leaf meal are under way at UAS, Bangalore.

The primary advantage is the high pigmenting property of the leaf meal. Even if five per cent of the good quality leaf meal is added in the poultry rations, the desired yellowyolk and yellow skinned broilers can be attained. The level of protein in the leaf meal varies from 20 to 35 per cent. Cattle consume the leaves, flowers, young pods and young shoots. It forms a very valuable supplement to grasses and crop residues by supplying protein, phosphorus, calcium and sulphur. In a recent feed lot fattening trial conducted at BAIF, Poona (Sobale et al., 1976), it was observed that cattle fed with soo-babul alone gave an average daily gain of 0.57 kg over other group of animals.

Drying of the cut forage reduces the mimosine concentration in the material. Therefore, soo-babul leaf meal can be easily dried in the sun. Cut branches are laid out on the ground or on wire netting racks. The green forage has to be spread with 5-7 cm thickness. It should be allowed to dry in the sun and the branches have to be turned over often. The other method is to cut the branches 15 cm above the ground level and leave them to dry in the field supported by the stubble. If additional support is necessary, it is provided. After 2-3 days, when the leaf lets are sufficiently dried, they are threshed off from the branches. They should be dry enough to crush easily by hand so that the leaf meal can be stored in stock without deterioration in its quality. The dried leaf meal can easily be milled in a mill. The advantages of milling are that the leaf meal can easily be mixed with other feed stuffs.

GRADES OF SOO-BABUL LEAF MEAL

1) UNSORTED LEAF MEAL : The unsorted leaf (including mid ribs), pods, flower heads and twigs of less than 6 mm in diameter dry enough to crush easily by hand

2) GRADE A : Pure, green leaf, dry enough to crush by hand. All pods, twigs, flower heads and rachises (larger mid ribs above 15 mm long are removed. together with most of the rachillae). When milled, this product is known as Grade A soo-babul leaf meal.

3) GRADE B : Dried mid ribs. pods, flower heads and small twigs remainings of the Grade A.

4) GRADE C : Any dry leaf meal product which has lost its green colour as a result of over exposure to the sun or as a result of rain or mould damage.

Table IV. pH and mimosine content of soo-babul leaf meal

	pH	Mimosine percentage
K–67	2.5	0.7
K–29	2.5	0.9
K–72	2.5	1.0
Cunningham	2.4	2.4
K–8	2.5	2.0
K–340	2.5	1.2

These grades are not related io protein values. However ungraded leaf meal has 25 per cent crude protein, A Grade has 30 per cent crude protein, Grade B leaf meal has 15 per cent crude protein, and C grade leaf meal has about 25 per cent crude protein.

Stall feeding of fresh soo-babul leaf meal in cattle stalls though advantageous is found to cause high proportion of wastage. However, dried leaf meal has valuable protein supplement for fattening cattle. In rural area even ungraded leaf meal can be used. It is reported by many workers that feeding of soo-babul leaf meal is a good as that of cotton seed

cake. Grade C leaf meal, even though dark brown in colour, is a valuable source of protein and is suitable for feeding to cattle.

USE IN POULTRY RATIONS : Grade A soo-babul is mostly used in poultry rations as a source of carotene or vitamin A. Mimosine toxicity is not a problem in Indian conditions. However rations for poultry or swine should not contain more than 5 per cent dried soo-babul leaf meal.

4. ORGANIC FERTILIZER :

It is needless to emphasize that due to continuous cropping of arable lands, the depletion of plant nutrients have to be supplemented either through organic or inorganic fertilizers. As the cost of inorganic fertilizers is very high, it is now felt necessary to supplement the plant nutrients through organic manures and nitrogen fixing leguminous crops. This practice is in vogue for a pretty long time. The legumes are the best source of easily decomposable vegetable matter. This is due to their high nitrogen content which varies from one half to one per cent of their green weight.

Growing soo-babul crop supplements nitrogen. phosphorus, potash and calcium in addition to small amounts of minor elements. For the maximum utilization of the nitrogen fixing powers of the legumes, inoculation of seeds with symbiotic bacteria is done. To get more fertilizer value from soo-babul, green manuring system is mostly advocated. This is also called as ''Transfer system.'' This means growing a crop in one plot and transferring it to another where usual crop is to be grown. However the crop should be harvested at the right age.In heavy rainfall areas with warm temperature, the application of fertilizers in organic state is preferred. As the production cost of forage of soo-babul is low, it is advantageous to adopt this transfer system to economise on inorganic

fertilizers. The soo-babul produces over 50 tons of green forage per hectare. It is desirable to build up the organic matter of the soil as well as the nitrogen content in the worn out soils. In Karnataka too, soo-babul green manure crop can be grown and information gleaned from the research centres can be applied to our local conditions. Considering the average yield of 50 tonnes per hectare of green manure amounting to 500 kilograms of nitrogen, the green manuring cost is cheaper than inorganic nitrogenous fertilizers. By adding to this, the value of organic matter and other plant nutrients the '' transfer system '' of green manuring is very advantageous. In Karnataka a detail investigation in this aspect is a must, at the present high cost of fertilizers.

Soo-babul has been grown as a soil improvement crop in plantations because of its high production of organic material and large amount of nitrogen. Mendoza and Semana (1976) reported that the harvest of soo-babul forage yielded 500 kg N/ha/yr with 200 kg P_2O_5 /ha and 450 kg K_2O/ha in addition to significant amounts of calcium and other minor plant nutrients. The great advantage of this ''transfer system'' is the addition of organic matter, increasing the water holding capacity and cation exchange capacity. Soo-babul can be grown on the site itself and ploughed **in situ** or under ''transfer system''. Thus soo-babul organic fertilizer can greately increase crop yields at low cost. However, more detailed investigation is needed in this aspect.

5. REFORESTATION CROP :

Soo-babul is being used to reclaim denuded waste lands, natural grass lands and marginal lands. As a grass land species, it competes with native grasses successfully. It is also a notable species for its soil building characteristics. It enriches the poor soils. As the plant sheds, its leaves form a valuable organic matter on the top soil. The roots penetrate into deep soil strata and utilize the plant nutrients and soi

moisture. It is fit for soil erosion control and water conservation. More economic utilization of the land is therefore attained. Soo-babul crop can be raised in all hill sides, barren lands, waste lands and other soils not fit for food crops. This does not mean that the crop could be raised in any type of soils. Reforestation cannot be undertaken in acidic soils and water logged areas. In acid soils, reforestation work can be undertaken after duly reclaiming the soils by application of lime, phosphorus and molybdenum. The quantity varies according to the soil reaction.

The immediate reforestation concern is the re-vegetation and rehabilitation of denuded lands located in water shed areas. Soo-babul survives even in unfavourable growing conditions. It is capable of fast growth compared to other species. Its rate of growth is incredible. The other desirable trait of the soo-babul species as reforestation crop is the economic utilization of the land. However, there are some difficulties in using soo-babul as a re-forestation crop, since a number of aspects such as varieties/strains suited for a particular area, time and method of sowing on the selected site, the optimum size of seedlings required for reforestation, cultural operations required on the site, spacing to be adopted and growing annual and perennial crops as inter crops are wanting which call for investigations.

6. WOOD PRODUCTION :

Tall varieties of soo-babul, erect with restricted basal branching are meant for timber. The tree varieties are also planted as hedges around farms. It has a relatively rapid growth and high potential value for fuel in regions where wood is scarce. At present, the wood of soo-babul is used as fuel wood, for charcoal manufacture and as props in banana plantations. The wood, can also be a source of pulp and paper, veneer and plywood, paraquet flooring

materials, construction lumber, poles, picker sticks and side level, particle board, hard wood and tanning. Knowledge about pulping and paper making, lumber making and plywood making from soo-babul is the need of the hour in the present crisis Wood properties also should be studied thoroughly. Some of the "Hawaiian Giant" strains are poor natural prunrs with knoty stems making the wood inferior. Several strains have been introduced from Hawaii and their adaptability has been studied since 1977. It is estimated that the caloric value of the wood either directly or after converting into charcoal is about 4000 calories per kilogram of raw wood. This can be improved upto 7000 calories for charcoal production. The soo-babul plants should be allowed to grow for one and a half years in order to get a good root system. Cut at the height of one metre, the product can be used for fuel wood and charcoal. However, technical and economic aspects of wood production and its utility have not been fully understood. In the light of existing information and knowledge, workable guidelines for the proper management of soo-babul plantations for wood production are given.

The Hawaiian Giants viz., K–8, K–72, K–67 attain a height of 12 metres with an average breast height diameter of 37 cm in 4 years. The species grown in dense stand shows rapid height growth during first two years. Vergera (1960) reported that the species seems to grow seasonally as it drops leaves during the hot and dry months producing concentric rings in the hard wood. Soo-babul plantations can be popularised in Karnataka in areas with distinct dry season periods of 4–5 months. Though the trees thrive well beyond 760 metres above sea–level they are not as productive as those of lower elevations. A study conducted by Almonte in 1956 reveals that the age of soo-babul is a factor in pulp yield and maximum pulp yield was obtained from six year old trees. Information is lacking on important

factors such as optimum levels of growth, yield and rotation for various wood uses. Wood quality is an important consideration and it refers to the suitablity for a particulars end product. The specific gravity is one of the important considerations while considering the physical properties of the wood. Rate of growth is a prime factor affecting the density of wood.

Information on physical, mechanical and chemical properties is considered very important since it can serve as basis in the utilization of soo-babul hard wood. Among the physical properties, such as specific gravity or density, grain pattern, colour, finish, thermal conductivity. thermal expansion, specific heat, texture, porosity and shrinkage specific gravity is most important. The fibre length of ''Hawaiian Giant'' soo-babul strains in more than that of the peru or local types.

Regarding the chemical properties viz., holo cellulose content, contents of ash, lignin, alcohol-benzene, hot water solubles, have not been fully analysed and research on these aspects are to be intensified early.

7. CHARCOAL PRODUCTION : The local and Hawaiian type soo-babul varieties/strains will be ready for charcoal production after four years. However, on introduction of ''Hawaiian Giant'' strains the trees are ready for charcoal after two years of growth. At this age, the trees attain an average height of six to eight metres and a breast height diameter of 10 to 12 cm. This size of tree is ideal and it can be cut by an axe. It is easy to convert into charcoal. Efforts should be made to find more efficient means of conversion of wood to charcoal. The most common method of making charcoal is by the pit method. The pit depends upon the length of wood to be burnt as well as the volume to be converted into charcoal.

Normally the wood is burnt for 24 hours, and the cooling process takes 36 hours.

The charcoal from "Hawaiian Giant" strains is sturdy and heavier in weight compared to other common varieties/ strains. The charcoal from branches can be easily broken into small charcoal chips. Experiments have to be conducted on making of charcoal from different varieties/strains of soo-babul and different methods of charcoal making. The main principle is that wood must be heated to drive away the moisture and volatile chemicals. The remaining part is the charcoal and is a very useful energey source for domestic and industrial use. The industrial use lies in its ability to supply the carbon atom. Its reactivity and conductivity makes charcoal a premium material. A thorough investigation on domestic and industrial use is yet to be done in Karnataka.

8. FUEL :

In the developing countries, the energy crisis has led to the study on the feasibility of generating energy from the energy plantations. Firewood has traditionally been the fuel for cooking food for most of the people. Only a small portion of the population in urban and rural areas cooks with kerosene, bottled liquified petroleum gas, gobar gas or electricity. Even now truck loads and wagon loads of fire-wood is hauled to the urban areas. The principal source is from natural forests. Now-a-days due to energy crisis, the prices of fuel have increased manyfold. The Governments have imposed price control systems on the fuel wood as it has become a scarce commodity. Eventually the retail prices will have to be re-adjusted to cope with the increase in cost. The only way to restore wood supply is through the planting of fast growing varieties of

trees. The most promising one amongst many species is soo-babul.

Fuel for steam and electrical power generation (except Hydro electric power) comes from coal and petroleum, Increasing costs of coal and oil will eventually force an increase in the cost of all products. Many are expressing alarm because of depletion of natural forests due to excessive cutting for fuel wood. Thus to overcome the energy crisis, there is a need for taking energy plantations in almost all denuded waste lands, hill sides, mountain slopes, waste lands and natural grass lands. The best species suited for all the situations is soo-babul. The establishment of new fuel wood plantations in addition to the already existing on a large scale would seem to be required to meet the expected large demand for fuel wood.

9. FIRE BREAK AND WIND BREAK

Fire has always been a major problem. Fire lines constructed each year at great costs are not very effective and short lived. Soo-babul planted very closely in strips of 5-10 metres width can provide an effective, inexpensive and year round fire break. It also serves as an efficient wind break. Soo-babul planted in wide strips, five to ten metre rows in natural grass lands, pastures, makes a dense stand with almost no undergrowth. This stand acts as a fire break and permits controlled burning of pastures or grass lands. The plant is also used as a wind break to prevent wind erosion in areas with light soils. It is used around vegetable and vine gardens at low elevation sites. Therefore by planting of suitable "Hawaiian Giant" soo-babul varieties, sizeable areas can be protected from fire and wind havoc.

10. FENCING AND SHELTER BELT

Soo-babul plants planted at one to two metre spacings make excellent live fence posts. Strips of Eucalyptus, "Hawaiian

Fig. 9 SOO-BABUL AS HEDGE PLANT AND SHELTER BELT

Giant'' plants and Casurina, one row each, all along the boundry act as a live Fencing as well as a shelter belt. Banana props and stakes for climbing crops could easily be produced by soo-babul if one by one metre spacing is adopted. Poles may also be cut to prop banana bunches or for use in light construction. Animals may also be allowed to browse and it looks ornamental too. Soo-babul crop supplements plant nutrients to the companion crops. The valuable attribute of soo-babul is its ability to withstand shaping, cutting and trimming to suit most desired uses. It can be maintained as a small tree in borders or hedges or as large trees in forest plantings. Two year old poles that are thinned out of plantations can be used as fence posts for gardens, farms and ranch. Even young untreated poles may last not less than two years. The fence can be made permanent if seedlings are planted between the fence posts. After two years, they serve as live fence. The chemically treated soo-babul fence posts remain for a number of years.

11. FIBRE :

''Hawaiian Giant'' soo-babul wood can be converted into paper pulp and hard board. It is estimated that 75 tons per hectare per year yield of wood means 12 tons of chemical pulp or 20 tons of hard wood. It is desirable that species have long fibre with a cell wall thickness and common width is less than one for the production of high strength paper. For lower strength, the craft pulp wood be an asset for its high opacity due to its short fibre pulp. It is reported that the pulp from the unbarked trunks of the seven year old K-28 strain and debarked one and a half year old trunks of ''Hawaiian Giants'' could be suitable raw material for pulp and paper. The low cost building materials such as fibre board and acceptable hard boards can be prepared. Soo-babul species can attain a size suitable for the manufacture of plywood and particle board.

12. DISTILLATE PFODUCTS :

The by-products of the exthermic cracking of wood are heat and volatile combustible matter. The carbonization of wood is the foundation for a wood Distillation Industries· (Bawagan and Semana, 1976).

The wood sugar produced from the industries with raw material of soo-babul can be used directly as an animal food. The wood sugar can also be fermented to produce ethyl alcohol. The fermented products are butyric acid and lactic acids, butyl and ethyl alcohols and glycerine.

Soo-babul wood can be burnt anaerobically to produce cocking gas and methyl alcohol. Since petroleum is a non-renewable resource, the Government may make it a requirement that a certain percentage of liquid fuel be obtained from wood. A detailed investigation in this aspect is the need of technology development to make the process more economic, efficient and competitive.

9. Nutritional Value

The soo-babul leaf meal is known for its high protein content. The high contents of crude protein and nitrogen free extract underline the considerable potential of the plant as a forage (Table V).

Kinch & Ripperton (1962) found that the leaf meal forage had an average crud fibre content of 29.8 per cent whereas the leaf fractions had an averege crude fibre content of only 14.3 per cent. Ths nutritional studies conducted at MRS, Hebbal, reveal that crude fibre content in leaf forage is 25.5 per cent with high nitrogen free extract of 40.95 per cent The details of chemical composition follow.

Table V. AVERAGE CHEMICAL COMPOSITION OF LEAF FORAGE OF SOO-BABUL

Dry matter	34.25	per cent
Crude protein	22.50	,,
Crude fibre	24.28	,,
Calcium	2.18	,,
Phosphorus	0.17	,,
Acid insoluble ash	0.80	,,
Total ash	7.92	,,

In ruminants, the rumen micro organisms are able to synthesize microbial protein of high biological value in the presence of adequate nitrogen and sulphur in the diet.

However, mimosine, β [N–(3–hpdroxypyridone–4)]–a–amino propionic acid occurs in shoots, stems and seeds of soo-babul. Owen (1968) has reviewed the literature on the toxic effects of Leucaena and reported hair loss in horses from mane and tail and loss of hair in pigs. However, there are no such reports from the studies undertaken at UAS and BAIF, Poona. It was postulated that the toxic action of the mimosine on growing hair was due to inhibition to tyrosine utilizing enzymes. Soo-babul leaf meal is very valuable due to its amino acid superiority to many other plant proteins. The toxic mimosine is found in all cultivated forms but its percentage has been considerably minimized in the newly evolved strains. Drying or heating of the leaf meal reduces the mimosine concentration.

There was a notion that soo-babul leaf meal feeding has adverse effects on animal health. The reasons for conflicting reports on the effect of leaf meal feeding can be attributed to the quantity fed to the animals. It depends upon the quantity of mimosine consumed per unit of body weight, the duration of feeding, the species concerned and the stage of the crop. No information is available on

the influence of soo-babul feeding on humans in India, although it is apparent that countries consuming soo-babul shoots as vegetable still have high brith rate. The toxicity can be reduced by adding ferrous sulphate to the diet. A detailed investigation has to be conducted in this behalf. The plant has been used for feeding fish in ponds but no adverse effects have been reported so far. The metabolism of memosine in fish is to be studied as the leaflets of soo-babul could form a valuable feed for edible fish production. It is reported that toxicity is negligible due to the degradation of mimosine to 3,4-dihydroxi pyridine (DHP) by micro organisms in the rumen of animals.

Soo-babul green fodder and leaf meal are being used for fattening the animals, enhancing milk production, as concentrated feed to the livestock, as a cheap source of protein supplement in place of concentrated feed, as silage and for browsing purpose, etc , However, further studies on the toxicity of soo-babul feeding on ruminants and non-ruminants have to be undertaken in detail for feeding to the livestock for a longer period.

10. Seed production Technology

It is alleged that unscrupulous seed merchants sell adulterated and uncertified seeds. New seeds are being made available for growers economically and commercially. In this respect, control on the movement of reproductive material must be initiated. To encourage the production and use of seeds, parts of plants that have been collected, transported, processed, raised and distributed must be ensured for their trueness.

The seeds of soo-babul are in pods. They open a few weeks after turning dark in colcur. Collection of pods should be made systematically in gunny bags before they

Fig. 10 EMERGENCE OF BUDS FLOWERS AND PODS

open. To thresh the seeds from the pods, the pods are spread on a dry, hard and well ventilated surface, preferably on concrete floor, After drying, the pods are stirred to release the seeds from the pods. Several methods could be employed in seed handling. The pods may be spread on an elevated screen with mesh wide enough to allow the seeds to pass through. A canvas cloth can be spread underneath the screen. As ths pods drive and open, the seeds fall on the canvas.

STORAGE : Before storage, the seeds should be thoroughly dried either by air drying with the aid of dessicants or with temperature controlled chambers. If the seeds are not dried properly, they are infected with seed insects (weevils) and fungi. The seeds should be treated with an insecticide such as malathion or metaxychlor and with a fungicide before storage in the seed containers.

Seeds lose fifty percent viability in four months if not stored properly. Seed moisture content should be down to 14 percent before putting in sealed drums. The ambient temperature required for storage is 10° C. Seeds stored, with 12 per cent moisture have remained viable for over, four years.

Soo-babul seeds are hard coated and the hardness of the seed coat increases the length of the storage. Seed treatment is needed before sowing the seeds. To obtain high and uniform germination, any one of the recommended methods can be followed. The seed treatment may be carried out by mechanical scarification of the seed coat, acid treatment, cold water soaking or heat treatment. Mechanical scarification may be conducted by using a drum lined with sand paper, and attached to a shaker or rotator. Seeds may be nicked by a knife without injuring the embryo or rubbing moist seeds against sand or stoney surface Treatment of seeds with commercial sulphuric

acid (80% purity) for five minutes and through washing with tap water also resulted in 90 percent germination. The seeds may be soaked in cold water for 48 hours and sown. This ensures 80 per cent germination. In case of hot water treatment, seeds should be dipped in hot water at 80° C for 5 minutes to soften the hard seed coat and to break the dormancy. After treatment, seeds should be dried rapidly and stored before planting.

Seed pelleting can be used to assure good establishment. Pelleting means mixing the inoculant with an adhesive solution. Coating the seeds with the adhesive inoculation solution and then adding a dry coating material in a concrete mix or by rotating them in a small bucket. Even fungicides may be added to the pellets. There is a need to develop techniques that are more efficient and to handle larger quantities of seeds. The optimum moisture content and temperature required for storing so as to prolong its viability will have to be determined.

There will be an increase in demand for seed material of soo-babul as tremendous interest is being shown by the farmers as well as industrialists.

The seeds of soo-babul plants are also being used to make ornaments such as necklaces, bracelets and hand bags. Soo-babul seed contains a galacto-mannon in relatively large quantity. This is a highly viscous gum used as a thickening agent and emulsion stabilizer in very low concentrations. The mimosine free seeds are also being used as human food.

A great emphasis has been laid on the usefulness of the soo-babul and people from all walks of life put up their demands for seed material. As the source of seeds is limited, it is logical to look to the demand and supply seeds to the

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needy persons. With the public welfare in mind, it becomes imperative to UAS to multiply the true seeds in all the Research stations and make the seeds available to the public. A well grown soo-babul plant/tree on a suitable site can produce at least 2.5 kilograms of seeds per tree within the first 18 months. One hectare of soo-babul plantation with 2 x 5 metres spacing will have 1000 trees. With 90 per cent survival, the approximate seed yield is 2000 kilograms per hectare. Each kilogram contains roughly 18,000 to 21,000 seeds. The number of seeds depends upon the species/strains.

To supplement production of quality seeds, it may be worthwhile to try vegetative propagation also. The use of vegetative parts for reproduction has the advantage of shortening the period of the planting to foliage or fuel wood harvesting. The other advantage is to check the weed menace at the initial establishment of the crop. However, using stem or branch cuttings results in very slow growth rate. Stem planting gives satisfactory establishment provided, planting is undertaken at the onset of monsoon. The vegetative propagation method has yet to be perfected.

Table VI. Test weight of different types of soo-babul seeds

1.	Salvador type	100 seeds	7.60 g
2.	Hawaiian Giant type	,,	5.20 g
3.	Peruvian type	,,	3.40 g
4.	Hawaiian type	,,	3.35 g

Source : Krishnamurthy and Mune Gowda 1981.

II. The need of the integrated researeh programme for soo-babul

In Karnataka, the technology available regarding soo-babul's utility is very limited. However, its potentiality for

multipurpose usage has been enlightened and the concerned as well as scientists have to initiate a planned national integrated research programme for this crop. Just like high yielding varieties of food grains, there are many high yielding soo-babul varieties. These can be used as fuel wood after 3 years. In the present-day energy crisis, the projection of fast growing soo-babul species favours an integrated research. With the present-day high cost of fertilizer, soo-babul is considered as a living factory of essential nitrogen. Compared to other legumes such as green gram, groundnut which contain only 0.5 per cent nitrogen. soo-babul has 4.0 per cent nitrogen in the foliage. With the available technology of "transfer system" for green manuring, it may be feasible to improve our farming system. Localized research programme based on soil and climatic conditions have to be planned. The establishment of large scale soo-babul plantations are the paths for discovering other uses of the species. Scientists of Forest Department, have to come up with preliminary findings regarding pulp, paper, wall board, particle board, and other novelties that are very promising products from soo-babul species. Scientists have to go hand in hand for investigating its uses. Projects have to be formulated for the establishment and utilisation for wood, feeds and the like. The following programme components may be considered at present.

The on-going research at UAS deals with available high yielding strains of soo-babul within the country and strains introduced from Hawaii, Philippines, Australia and USDA, Maryland, USA. There is an urgent need to formulate an integrated research on the following projects.

i) VARIETAL INTRODUCTION, SELECTION OF SEED AND SEED PRODUCTION TECHNOLOGY: In general, the high yielding strains are adapted

to lower elevations. The soil reaction is also confined to limited range. With the heterogenous characteristics of soils, varying degrees of exposure and elevations, different climatic conditions from one locality to another prevailing in the state, it is necessary to develop appropriate varieties for specific uses. In the long run, improvement of selected strains makes easier seedling production and crop establishment. Strains for pulp, and new strains with negligible mimosine content for animal feed have to be identified.

ii) INDUSTRIAL USE : For industrial use, suitable strains have to be isolated for growing on different sites. It will ensure high survival and faster growth. It is necessary to explore the potential of number of strains as cover crops, nurse crops, fast growing hard wood, most promising short fibre hardwood for pulp etc.

iii) MANAGEMENT SYSTEMS : Management for timber and pulp wood production and other uses, water shed rehabilitation purpose, suitable management systems have to be identified. So that relevant areas can be demarked for the source of hydro-electric power and water reservoirs for industrial and domestic uses.

iv) PROJECT ON WOOD : Now the wood of soo-babul is being used as fuel, as a source of charcoal and as props. The leaves are used as feed supplement to the livestock. These present uses do not increase the utilization of this renewable resource. The wood

can also be a source of pulp, paper, veneer, plywood, lumber, timber, poles, picker sticks, particle board, hard wood and tannins. Knowledge on these anatomical, physical and chemical properties of the high yielding strains enlighten the industries. Hence, further wood properties should be studied thoroughly.

v) FORAGE AND SOIL AMELIORATION : One should realise the great potential of soo—babul for livestock feeds and its use for soil improvement. The research should be focussed on the inter-related factors that affect the crop establishment in open grasslands or range lands. The attention has to be focussed on soil factors and growth association with various pasture vegetation. The cutting/defoliation management system has to be studied in detail related to herbage yield and quality. The utility aspect as green fodder, feasible techniques in processing soo-babul leaf meal and feed supplements for future use shall also be studied. Research should also be focussed on determining combinations of operations that would lead to maximum utilization for green manuring or as fertilizer.

vi) ECONOMICS : It is necessary to study the feasible production and utilization techniques for specific uses. The investigation on multi-stage costing both from wood and non—wood products has to be worked out. It is necessary to choose the best business alternative. The actual cost—benefit ratio has to be worked out for a particular situation.

12. Dissemination of soo - babul technology

Considerable work on soo-babul development has been initiated and the benefits derived from this crop are now known to several farmers. However, extension activities should be taken up to show this plant as a multi—benefactor. A number of popular articles are being written by the workers engaged on this crop. There is a need to enlighten the interested growers regarding its utilization. Much has to be done in the area of agronomics, processing and economics. Comparative economics in production processing, utilization and marketing would help in spreading soo-babul technology.

Research is different from technology. Research produces technology. It focusses on specific problems to seek solutions. The research results need to be packed into technology in order to be beneficial to people in terms of goods and services of economic importance. Even though some technology is available, much more is to be generated from research on this crop. Much has been said about the uses of soo-babul tree as forage, feed, food, fibre, manure, fire break, fencing, fuel, and film. Data are not available to make possible, the packaging of the information into technology and therefore further investigations are required. Thus soo-babul development would on a larger perspective contribute to agricultural development and rural prosperity.

Information on soo-babul technology needs to be disseminated not only for the benefit of the users of the technology but also for the benefit of scientific workers. The UAS is interested in on-going and completed research programmes and in disseminating the technology to the

needy people of the state. The spread of soo-babul technology could easily become part of a series of technologies that are required in integrated rural development. The improvement of the quality of life means the use of many and varied technologies.

13. Summary

Soo-babul, LEUCAENA — LEUCOCEPHALA, is a leguminous shrub/tree for food, feed, pulp, fibre and such several uses. It originated from Central America, Mexico. In 1581 the Spanish galloen trade came to philippines and crossed the Pacific Ocean. It became the widely naturalised animal browse tree in South East Asia. Earlier it was a shade tree in plantation crops and later on it was recognised as a source of nitrogen, fibre, pulp, wood and charcoal. Soil erosion control, soil and moisture conservation and soil reclamation are the other contributing characters of soo-babul. Four species of trees grow upto 20 metres and are meant for shade and browsing purpose. The remaining species are low shrubs generally under 5 metre in height. The leaf-let size varies greatly from species to species. All are non-thorny, high in leaf protein and generally attractive to the animals. Although it has been called by many names around the world the common name "Leucaena" is preferred internationally. There are four types of soo-babul, namely "Salvador type', "Hawaiian type", "Peruvian type" and "HawaiianGiants". Salvador type trees are often 20 metres in height. The "Hawaiian type" shrubs are rapidly flowering, highly seeding throughout the year and grow upto 5 metres. The "Peruvian type" trees are tall, 15 metres in Height with basal branching, big flowers, pods and seeds. The "Hawaiian Giant" soo-babul trees were discovered in 1910. They are distinguished by larger stems, leaves and pods. Peruvian type are favoured for pasture and forage purposes.

Soo-babul crop is mostly adapted to low to moderate rainfall regions and low elevations. The growth is restricted by very low temperature. It thrives well on slightly acidic to slightly alkaline soils with pH of 5.5 to 8.5.

The bushy non-photo-periodic early maturing and heavy seeding types are valuable for forage and reforestation under adverse situations. For timber production, taller growing types with restricted branching and photo-sensitive species have to be selected. The soo-babul species are known to inhabit a wide range of topography and soil types with all sorts of soil features. In this varied habitate these plants also exhibit varying degrees of growth and development. One draw back of soo-babul is its relatively slow seedling growth. Any steps undertaken to accelerate seedling growth and reduce early weed competition are useful. They include good land preparation, seed treatments, fertilization and irrigation. Land can be tilled or not tilled depending on the situation. For reforestation crop or pasture, tillage is not necessary. For erosion control, site preparation has to be undertaken by digging pits for transplanting seedlings or opening of strip furrows to sow the seeds. For more intensive management systems namely for intensive pastures, inter cropping, and green manuring, preparation of a good seed bed is a must.

Soo-babul seeds have a thick waxy seed coat requiring scarification or special seed treatment to ensure good germination. Seeds may be treated by mechanical scarification, heat treatment or acid treatment. The easiest method is immersion of seeds in hot water (80° C) for 5 minutes.

Soo-babul requires inoculation with a specific strain of RHIZOBIUM bacteria. Right type of culture is required

for acid, neutral or alkaline soils. Seeds may be dibbled, drilled or broadcast depending on the site preparation and the purpose for which the crop is grown. Seed rates vary depending upon the intended use and row spacings.

Seedlings may be raised in nurseries or pots or in containers and transplanted into the field. Care should be taken to ensure that adequate plant nutrients are supplied.

The most suitable time of sowing/planting is the beginning of the rainy season. According to the local situations, sowing/planting operations can be adopted. The spacing depends upon the management system and the local environment. Mostly soo-babul is sown/planted in rows but for reforestation, in pasture or denuded lands broadcasting method is used. Row spacing varies widely. Each management system will require its own spacings. Weed competition should be checked at the initial period of crop establishment.

Although soo-babul is a drought tolerant crop, one or two irrigations are required at the time of establishing the crop. Moisture should not be the limiting factor for forage yield. Forage yield during the dry season decreases under rainfed condition. Soo-babul withstands repeated defoliation either under cut and carry system or grazing. Plants can be harvested at a height of 15 cm to 150 cm after six months of planting. Low heights of cutting result in weeds competition and higher cutting heights is desirable either for silage or green manure cropping systems. During the summer and rainy seasons, the harvest interval is 50 days and in winter months it is prolonged to 70 to 100 days. In most of the management systems, the number of cuttings per year varies from four to eight.

Soo-babul's utilization aspect to a person's life is from "birth to death". The important items are forage,

pasture, animal feed, wood production, reforestation crop, charcoal production, organic fertilizer, fire and wind break, fencing and shelter belt, fuel, fibre and distillate products.

For completion of one growth cycle, normally it takes about six months. Two systems are adopted. One is cut and carry system, once in 50 days which produce 80–100 tons green forage per hectare per year. The other system is browsing in a scientific rotational method. As the forage contains high crude protein, cattle fed with soo–babul green fodder produce more milk and also increase their body weight. The experimental results reveal that the body weight per day was increased by one and a half kilogram at MRS, Hebbal, Bangalore and BAIF, Poona. Green fodder could be made available during summer season when it is normally scarce. Supplying green fodder to the livestock by the small farmers means improvement in their socio–economic conditions in the society by obtaining more milk and meat gains.

Soo-babul may be set in the field in pure stand or mixed with grasses. The nature of the leaves allows sun-light to filter its canopy. Grasses interplanted with soo-babul will carry one animal per 0.4 hectare. Rotational grazing system is mostly advocated. For grazing purpose shorter bushy types should be grown rather than the tree types. Grazing should not start till the plants are one metre high. Because of high palatability, soo-babul pastures are easily over grazed. Careful management is necessary.

Soo–babul leaf meal is well accepted by livestock. The leaf meal consists of the leaves, flowers, young pods and young shoots. It forms a very valuable feed supplementing protein, phosphorus, calcium and sulphur. Very high live–

weight gains and higher milk production From rations of soo-babul was observed. Leaf meal can be graded as A, B, C and ungraded categories.

The wood derived from soo-babul energy plantations can play a dominant role during this energy crisis. The only way to restore the wood supply is through the planting of fast growing soo–babul, Hawaiian Giant varieties. Establishment of new energy plantations to meet the public demand for wood is the need of the hour. The soo-babul trees will be ready after two years of growth to be converted into wood charcoal. The charcoal from big soo-babul tree trunks is sturdy and heavier in weight than other tree species. For conversion, pit method is generally adopted. It is very useful as domestic and Industrial fuel.

Soo-babul possesses salient features for reforestation and land reclamation. Its wide adaptation to wide range of scils and rainfall belts, easy establishment, fast growth rate, wide adaptability with forest tree species makes it useful for reforestation. The gregarious plant growth with ratooning capability provide shade to young tree seedlings and suppress the weed growth. Site preparation in not needed and the crop can be established either by sowing seeds or by transplanting the aged seedlings. The plant is being used to reclaim waste grass lands.

The plant has been grown as a soil improvement crop. The green material contains 4.0 per cent nitrogen and it is estimated that it adds 500 kg N, 200 kg P_2O_5 and 450 kg K_2O per hectare per year. It also adds substantial amount of calcium and increases water holding capacity of the soils. Considerable amount of organic fertiliser is added into the soo-babul grown lands. The plants can be planted in wide strips in grass lands or in pastures. The Giant varieties make a dense stand and act as a fire break. This allows controlled burning in pastures.

Planted at one metre spacing, soo-babul makes excellent live fence posts. Poles derived can also be used as banana props and stakes for climbing crops. It also acts a shelter belt if planted in strips or trenches or contour furrows. Soo-babul wood being a high density wood, makes an excellent fuel wood. During this energy crisis period, soo-babul energy plantation can provide the required renewable energy resource at cheaper cost. Wood from "Hawaiian Giants" can be converted into paper pulp and hard board. A 75 ton wood per hectare per year yields 12 tons of chemical pulp or 20 tons of hard board. The other interesting fact is that the wood can be hydrolized to sugar and sugar fermented to alcohol which can be blended with gasoline to run internal combustion engines. The wood can also be dried in the form of small blocks and be fed to wood gas generator. The gas so produced is used to run diesel and gasoline engines. These aspects need thorough investigation through integrated national research programmes. At present, the research programme on soo-babul is confined to forage and fuel wood only. The UAS has to handle all studies dealing with establishment, management, utilization and dissemination of technology of the crop. The socio-economic studies are yet to be initiated. Therefore, an integrated project on varietal introduction, selection and seed production technology, silviculture aspects, management system for wood production and utilization aspects, forage and soil amelioration have to be formulated. The possibility of using it as a multi-benefactor to the mankind should be explored.

Soo-babul forage is a valuable source of crude protein, vitamins and minerals. The leaf meal is valuable due to its amino acid composition which is superior to many other plant protein sources. The leaf meal can be used as poultry and swine ration. The loss of carotene was observed in stored leaf meel. To derive benefits from the soo-

babul crop, the research results gleaned should be packed into a form of technology and should be disseminated to the needy people for exploitation of the soo-babul crop as a multi-benefactor. Research produces technology and it focusses on specific problems to seek solutions. The literature should be brought out which should cover the agronomics, utilization and economic aspects of soo-babul crop and made available to the commuters.

14. Future line of work

Ecological problems with dwindling natural resources warrant increased food production in the available arable lands. To meet the demands of food and energy, new agricultural and forest systems must be developed. Therefore, research on agro-forestation by growing perennial tree crops coupled with annual food crops can offer an answer to many of the problems in hill side farming.

Much has been done in the areas of agronomy, processing, utilization and economics, yet there is a dearth of information on the above cited disciplines. Much more research is needed to generate information on all aspects.

Three areas of research namely production, utilization and reforestation have been identified. The production research involves inputs for establishment, cultural practices and production of wood for fuel, charcoal, lumber, pulp, paper, fibre boards, plywood, particle boards and distillates. An integrated research project has to be formulated at the institutional level.

Utilization aspect cover both the basic and applied research. It needs integrated research to investigate the

physical, mechanical and chemical properties of wood and other by–products of the tree.

For reforestation programme, use of soo-babul as cover crop, shade trees and green manure in established plantations have to be investigated. Combination of soo-babul and agricultural crops in hill side farming for maximizing land use has to be substantiated by formulating multi-disciplinary projects. Species suitable for various uses to mankind have to be identified.

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8	5	arboreal of	arboreal form of
8	12	Yucation	Yucaton
12	19	All	An
17	8	fell	falls
17	23	excect	except
33	9	than	then
33	15	with days	with 50 days
34	22	vitamin A	vitamin K
35	28	stock	stacks
36	last	a good at	as good as
40	7	prun rs	pruners
41	15	in	is
45	25	with a cell	with a double cell
45	25	common	lumen
45	26	width is less	width diameter is less
46	2	exthermic	exothermic
46	4	for a wood	for wood
50	8	drive	dry
51	1	through	thorough
56	23	dackaging	packaging